#2117

United States
Department of
Agriculture

Forest Service

Alaska
Region

FOREST HEALTH PROTECTION REPORT

Decay of white spruce in pre-commercially thinned stands in Tok, Alaska

Biological Evaluation R10-TP-78
May 1999

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BIOLOGICAL EVALUATION R10-TP-78

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INTRODUCTION

Forestry staff from the Tanana Chiefs Conference, Inc., (TCC) have been conducting pre-commercial thinning operations in a white spruce (*Picea glauca*) stand on Native allotments near Tok, Alaska. This work was a Forest Development project intended to increase the economic value of the forest for the Native landowner. During felling operations, thinners noted substantial decay in many felled spruce trees but were unable to predict which live standing trees contained decay. The concern was raised by TCC Forestry Staff that thinners may be inadvertently choosing some trees with decay as leave trees. Since the objective of the thinning was to increase volume growth of the leave trees, retaining diseased trees could seriously interfere with management objectives.

In June 1998, Anchorage Forest Health Protection (FHP) staff and Robert Ott, TCC Forestry Staff, conducted an evaluation of several thinned and unthinned allotments. The objectives of the evaluation were to: 1) identify the causal agent(s) of internal decay in white spruce; 2) determine the incidence of the causal agent(s) across the allotments; 3) on live standing trees, identify the external indicators that may be reliable predictors of internal decay.

Site Description

Thinning operations occurred in a white spruce stand located on a 165 acre Native allotment that has been subdivided into 8 smaller allotments (Figure 1). The stand is located on the south side of the Alaska Highway, 5.3 miles west of the community of Tok. The spruce stand originated from a fire that occurred about 80 years ago. Patches of remnant trees from the previous stand are present. The site index is 60-65 (index age of 100 years).

Prior to thinning, the density of trees >4.5 feet tall averaged about 4,700 stems/ acre. Density of trees ≥ 2.0 inches diameter at breast height (dbh) averaged 875 stems/acre. The stand was comprised of 90% white spruce and 10% quaking aspen (*Populus tremuloides*). After thinning, tree density averaged 568 stems/acre, at approximately an 8.8 feet x 8.8 feet tree spacing. The average tree dbh after thinning was 3.8 ± 1.8 inches. The stand was comprised of 96% white spruce and 4% quaking aspen.

METHODS

Destructive sampling surveys were conducted in allotments 2, 3, 4, and 5 (Figure 1). In thinned portions of allotments 2 and 5, 526 spruce stump tops within 2 - 1/10th acre plots, were freshly cut and assessed for the presence of decay. In a walk-through survey of allotments 3 and 4, 18 undiseased live trees and 10 diseased live or recently dead spruce trees were visually located, dissected, and assessed for dbh, total height, height to live crown, decay column length and presence of external indicators including multiple live or dead leaders and fruiting bodies.

In an unthinned portion of allotment 3, a 1/8th acre square block (41 ft x 41 ft) of spruce was thinned to an 8 x 8 foot spacing. Fifty of the thinned spruce trees were dissected and assessed for decay incidence and presence of external indicators. Data were recorded for dbh, total height, and height to live crown on 10 healthy and 2 diseased live spruce trees.

RESULTS AND DISCUSSION

Fungal Incidence, Identification, and Biology

The primary decay organism in the Tok allotments was *Phellinus chrysoloma*, a wood decay fungus that causes a white pocket trunk rot. Surveys indicated that this heart rot fungus occurred at low frequencies, with decay present in 3% (18 of 526) of the inspected stump tops in allotments 2 and 5, and in 8% (4 of 50) of the thinned trees in allotment 3. Two other decays were present in allotment 3; root rot caused by *Inonotus tomentosus* and an unidentified white stringy butt rot. Both decays were present only once in the surveys.

Until the 1970's, *Phellinus chrysoloma* was considered a variety of the red ring rot fungus, *Phellinus pini*, but it is now recognized as a distinct species (Gilbertson and Ryvarden 1987). Early disease surveys in Alaska considered *P. pini* one of the most common and possibly the principal fungus causing heart rot of the main bole of white spruce in Alaska's interior spruce forests (Kimmey and Stephenson 1957). More recent surveys indicate that both *Phellinus* species occur in Alaska's spruce forests (Volk et al. 1994).

Phellinus chrysoloma was identified by conks, punk knots, and macroscopic characteristics of the stain and decay (Appendix A). Conks and punk knots (swollen knots filled with mycelium) occurred on 36% (5 of 14) of dissected diseased trees. When present, the small bracket-like conks developed in clusters on lower tree boles, within 2 feet of the ground level (Figures 2 and 3). Conks issued from the underside of old branch stubs or from cracks in the bark. On recently dead and downed trees, conks were flattened and developed in rows. Sunken resinous stem cankers, caused by the fungus (Owens 1936), developed on two infected trees (Figure 4).

Decay column length in *P. chrysoloma* infected trees ranged from 0.5 to 24 feet with an average of 10 feet (± 6 feet). In all but one dissected tree, the stain and advanced decay were clearly visible at the stump surface, with the decay column extending from the base of the tree up the bole (Figures 5 and 6). In only one tree, the lowest extent of the decay column was visible 8.5 feet above ground level.

Visible decay at the stump surface suggested: 1) the presence of a fungal infection court low on the tree; and 2) stump top surveys were a reliable method of assessing incidence of the heart rot fungus in the Tok allotments. Typically, complete bole dissection is needed to accurately assess heart rot incidence, however, stump top surveys were adequate in the Tok allotments because of the presence of decay close to the ground level.

Multiple live and dead forked branches of the main stem, greater than 0.5 inches diameter, and stem crooks, occurred on nearly 75% of the diseased trees at 1 to 2 feet above ground level. This suggested that the fungus gained entrance to the main stem primarily through the low dead branches, as suggested for *P. pini* by Percival (1933). Similar to the red ring rot fungus, *P. chrysoloma* typically infects trees after heartwood has been produced (Etheridge 1972), approximately 40-50 years. There are reports of conifers infected by red ring rot as young as 27 years old (Boyce 1953).

The origin of the multiple forks and stem crooks, indicative of early injury to the main stem, was likely due to winter browsing by animals. There was old evidence of snowshoe hare (*Lepus americanus*) browse on the tips of many lower dead branches and terminal leaders of

mature trees. Recent browse damage by hares to the main stem of young seedlings was apparent across the surveyed units. Hares are known to feed on spruce twigs and needles during the winter months.

In our survey, one single-stemmed tree with a dead witches-broom, caused by the spruce broom rust fungus (*Chrysomyxa arctostaphyli*) and with no other apparent entrance courts, contained a substantial decay column that tapered above and below the broom (Figure 7). Although infection by spruce broom rust does not cause cambium death, the production and subsequent death of multiple branches at the site of infection may provide an entrance court for wood decay fungi. *P. pini* can enter trees where the cambium has been killed by rust fungi (Blanchette 1982). Dead portions of trees infected by spruce broom rust are susceptible to wood decay fungi, including *P. chrysoloma* (Hennon 1987). It is unknown how frequently fungal-induced brooms provide infection courts for heart rot fungi.

Decay Indicators

The most conspicuous and reliable external indicators of heart rot decay were conks and punk knots, although less than half of the infected trees produced them. The production of conks is related to the length of time a tree has been infected and various environmental factors. Conk production in infected trees is expected to increase over time in the Tok allotments.

Live and dead forks and stem crooks occurred in 71% (10 of 14) of the dissected diseased trees and 52% (33 of 63) of healthy trees. Of those trees with forks, 75% of the diseased trees and 12% of the healthy trees contained dead forks >0.5 inches in diameter. Forks and crooks consistently occurred at one to two feet above ground level. Evidence of old and fresh resin flow at the union of forks or crooks occurred in 57% (8 of 14) of the diseased trees and in 27% (17 of 63) of the healthy trees.

Four diseased trees were single-stemmed, lacking forks or stem crooks. One diseased tree had a distinctive basal swelling, two contained sunken resinous cankers on the main stem, and one contained a dead broom caused by spruce broom rust. Basal swelling, cankers, or dead brooms did not occur in any healthy trees, although live brooms were noted in two trees.

Bark beetle galleries occurred in 79% (11 of 14) of the *P. chrysoloma* infected trees and 2% (1 of 63) of the non-diseased trees. The single attacked, non-diseased tree was unthrifty, with a dead fork at one foot and copious resin flow at the base. The bark beetle was tentatively identified as the Allegheny spruce beetle, *Dendroctonus punctatus* (E. Holsten, pers. comm.). This beetle is known to attack the lower bole of white spruce in Alaska, killing scattered trees principally in non-commercial stands. The adult Allegheny spruce beetle is indistinguishable from the adult spruce bark beetle, *D. rufipennis*, except for genitalia. Since beetles were not collected, a positive identification was not made.

Interactions between bark beetles and pathogens have long been recognized and documented (Cobb *et al.* 1968; Partridge and Miller 1972; Hertert et al. 1975; Lane and Goheen 1979; Livingston *et al.* 1983; Kulhavy *et al.* 1984). The relationship of *P. pini* infection as a predisposing factor for bark beetles was suggested by Rudinsky (1962) who associated the occurrence of heart rot caused by *P. pini* with increased susceptibility to attack by bark beetles. Thus, an association between *P. chrysoloma* and attack by the Allegheny spruce beetle in the Tok allotments is not surprising.

Small, old, callused wounds, averaging 10 in^2, occurred on the bole of 7% (1 of 14) of the dissected diseased trees and 13% (8 of 63) of the healthy trees. *P. chrysoloma*, however, did not appear to require a wound to gain entrance to tree boles. Total height, dbh, and percent of live crown did not differ between healthy and *P. chrysoloma* infected trees for 40 dissected trees randomly selected from an unthinned portion of the allotments (Table 1).

Table 1. General Tree Characteristics for 40 Dissected Trees.

Tree type	n	dbh (in.)	Total Height (ft)	Live Crown (%)
P.chrysoloma infected	12	2.8 (0.9)*	22 (6)	53 (13)
Healthy	28	2.8 (0.9)	22 (7)	52 (16)

* Mean followed by standard deviation in parentheses.

In summary, the most conspicuous and reliable external indicators of decay were the presence of conks and punk knots, although fewer than half of the infected trees produced them. Thus, surveys for conks and punk knots alone will likely underestimate decay incidence in a stand. Trees with the following characteristics may be infected by *P. chrysoloma* and should be further inspected for evidence of conks and punk knots: 1) dead stem forks or branches greater than 0.5 inches in diameter; 2) stem crooks; 3) sunken stem cankers; 4) fresh or old resin flow at forks or crooks; 5) evidence of attack by the Allegheny spruce beetle; and 6) dead witches-brooms induced by spruce broom rust.

Infection by *P. chrysoloma* did not appear to be associated with the presence of bole wounds, total height, dbh, or the proportion of live crown. While wounds do not appear to be an infection court for *P. chrysoloma*, poorly healed wounds can be infection courts for other wood decay fungi.

Management Implications

Currently, less than 10% of the white spruce trees in the surveyed Tok Native allotments are estimated to be infected by *P. chrysoloma*, a wood decay fungus that causes a white pocket trunk rot. Within infected trees decay columns are substantial, currently averaging 10 feet in length. Decay columns will likely expand radially and vertically within infected trees in the future.

In mature spruce trees, the incidence of *P. chrysoloma* is not anticipated to increase much beyond the current levels in the near future. Currently, conks were produced on less than half of the infected trees surveyed and, although conk production is expected to increase in the future, the clustered fruiting bodies will likely be produced low on the tree bole. The low position of the conks will greatly reduce the effective distance of spore dispersal from conks to uninfected trees. Also, the presence of *P. chrysoloma* decay appears closely tied to injury of the main stem. The injury is manifested as multiple forks and/or stem crooks on a tree bole. At present, few mature trees in the stands surveyed have recent injuries of the main stem that could potentially become an infection court for *P. chrysoloma*. Recent damage from snowshoe hare browse, however, is

apparent on seedlings across the units. Thus, the incidence of the fungus may increase in the young generation of trees that is currently subject to snowshoe hare browse.

TCC has developed standard thinning guidelines for crews to utilize during thinning operations. The guidelines are intended to maximize conifer survival and retain spruce trees with a high expectation of release after thinning. The guidelines are as follows:

Achieve an 8 foot x 8 foot spacing, while retaining crop trees with these characteristics:

1. Straight bole -- no crook or sweep
2. Single stem -- no multiple tops
3. Disease free -- no open wounds, cat faces, excessive scarring, or witches-brooms
4. Generally healthy with a full crown
5. Relatively fast growing -- generally the largest tree in the growing space

Based on the results of this study, adherence to TCC's standard guidelines by thinning crews is expected to substantially reduced incidence of *P. chrysoloma* in leave trees. Future disease problems with *P. chrysoloma* in the Tok thinning units can be mitigated with well-trained crews carefully inspecting and removing spruce trees with external decay indicators, including dead stem forks or branches greater than 0.5 inches in diameter, stem crooks, sunken stem cankers, fresh or old resin flow at forks or crooks, attack by bark beetles, and dead witches-brooms. Trees with external indicators may be infected by *P. chrysoloma* and should be carefully inspected for evidence of conks or punk knots.

P. chrysoloma conks can survive for some time on dead trees. Removal or burning of felled trees with conks will reduce spore dispersal from conks to uninfected trees. Stump top surveys are an effective tool for crews to use to estimate incidence of *P. chrysoloma* across a thinned stand. Wood decay caused by *P. chrysoloma* occurred close to the ground level in the Tok allotments and was conspicuous on stump surfaces.

ACKNOWLEDGMENTS

We thank Vaughn Salisbury and Karola Ruter for assistance with field work.

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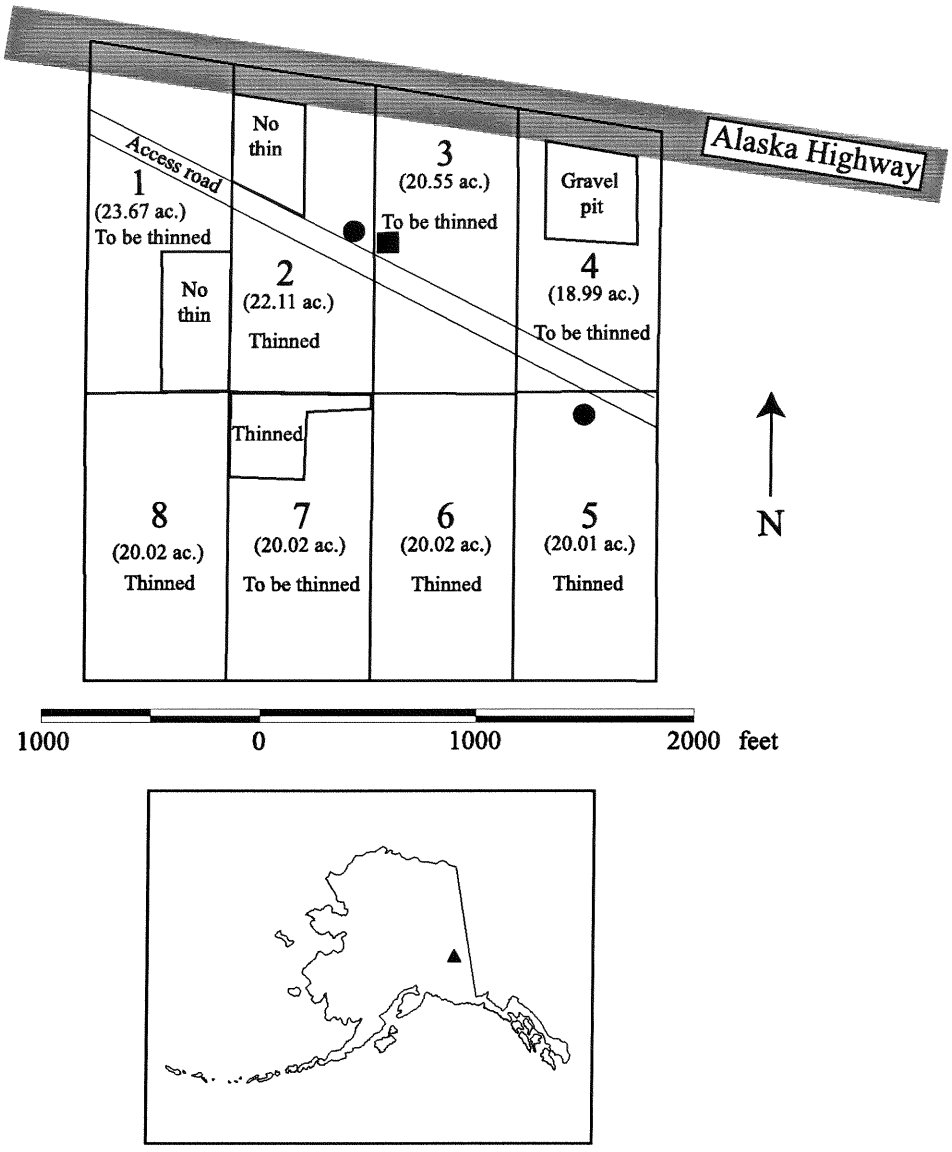


Figure 1. Native allotments (1-8) where decay of white spruce in pre-commercially thinned stands was characterized. Circles indicate where stump top surveys were conducted. The square indicates where the sample thinning was conducted. The study area location in the map inset is indicated by the black triangle.

Figure 2. *Phellinus chrysoloma* conks fruiting in a cluster on the lower bole of white spruce. The ruler at the base of the tree is 6 inches long.

Figure 3: Perennial conks of *P. chrysoloma*.

Figure 4. A resinous stem canker caused by *P. chrysoloma*.

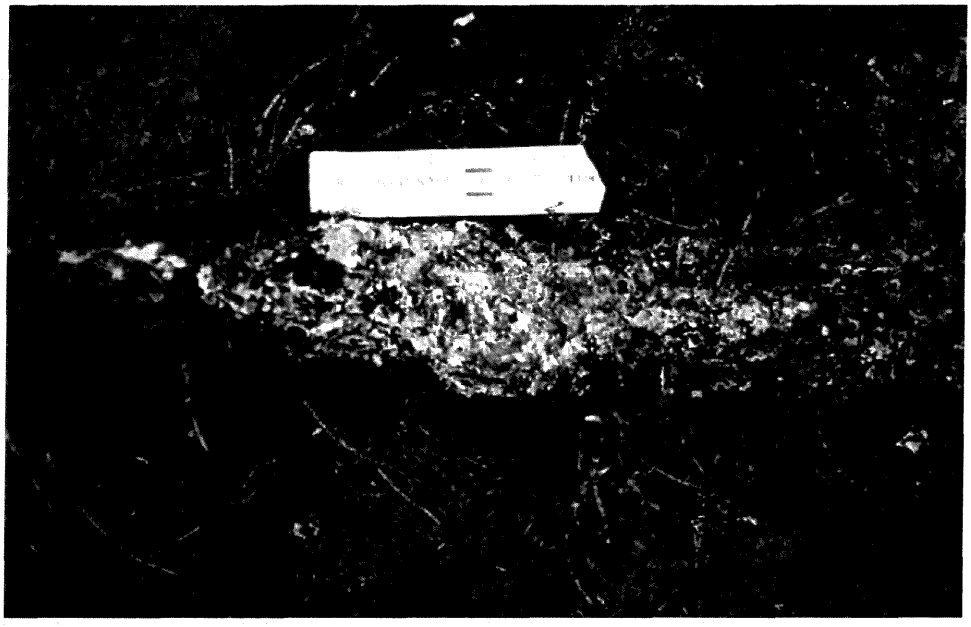


Figure 5. Incipient decay caused by *P. chrysoloma,* a prominent discoloration of the heartwood which generally follows the annual rings.

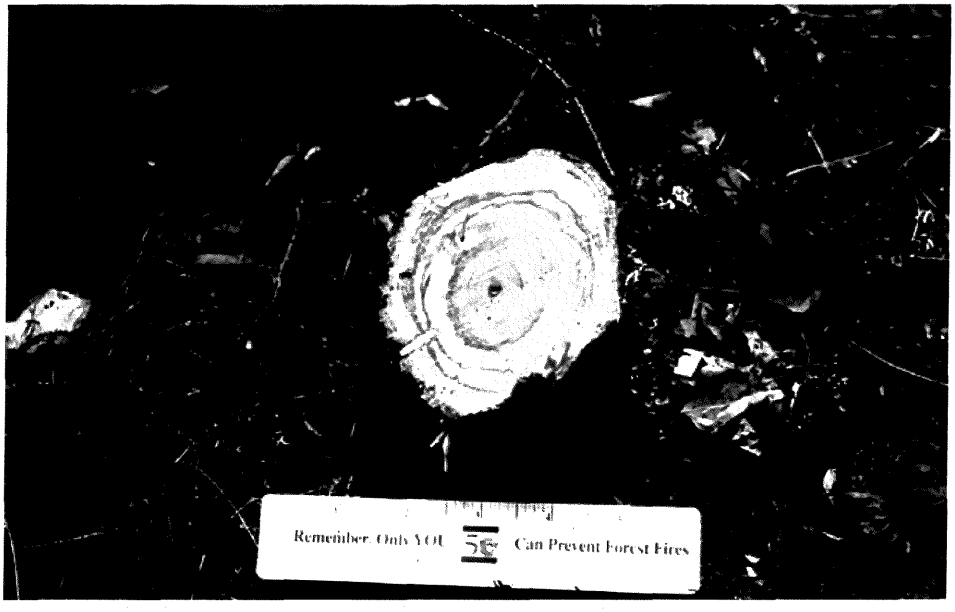


Figure 6. White pocket advanced decay caused by *P. chrysoloma.* A decayed branch stub, also called a punk knot, is outlined with a heavy black line.

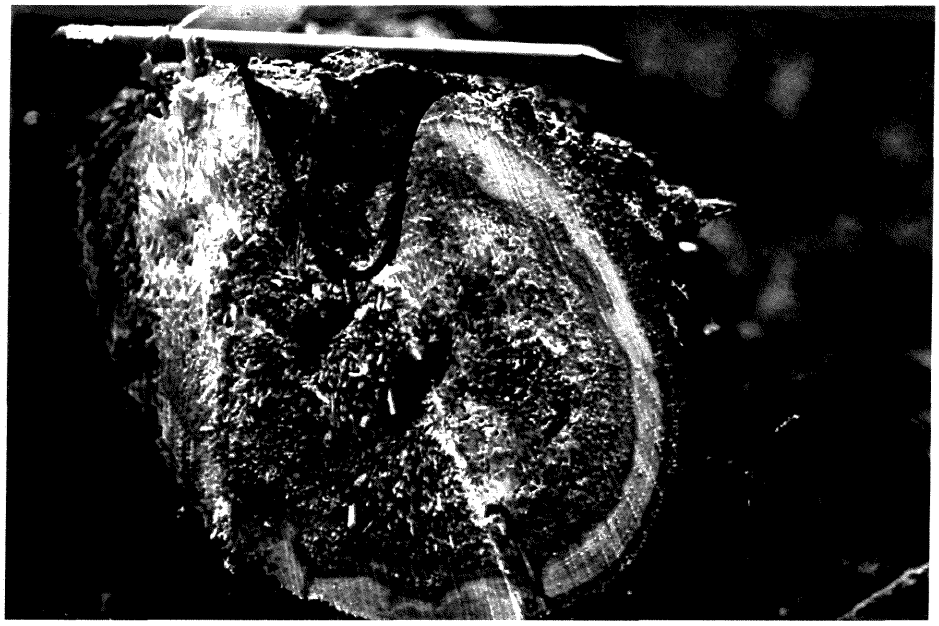


Figure 7. *P. chrysoloma* advanced decay in association with a dead spruce rust broom.

Figure 6. White pocket advanced decay caused by *P. chrysoloma.* A decayed branch stub, also called a punk knot, is outlined with a heavy black line.

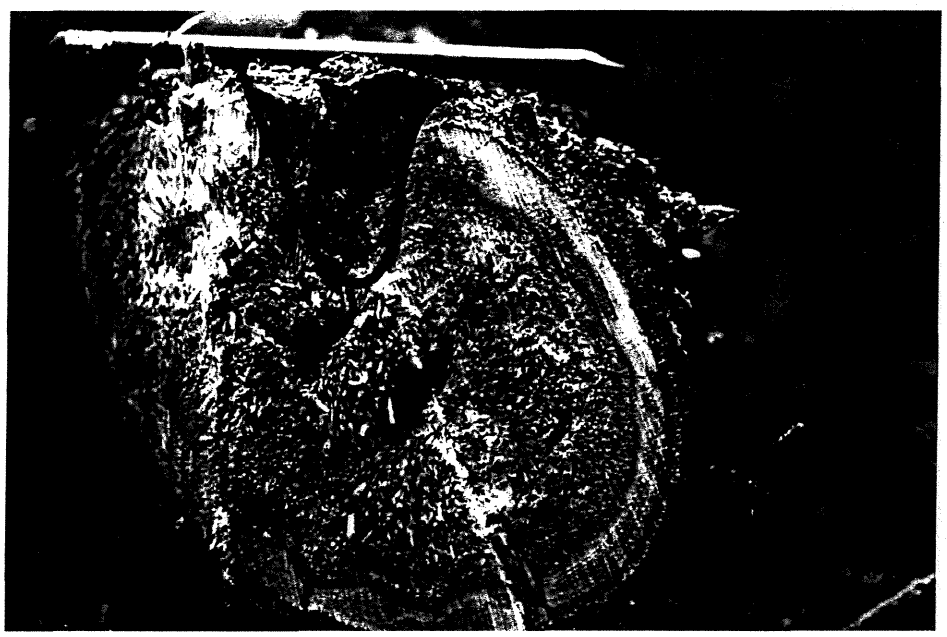
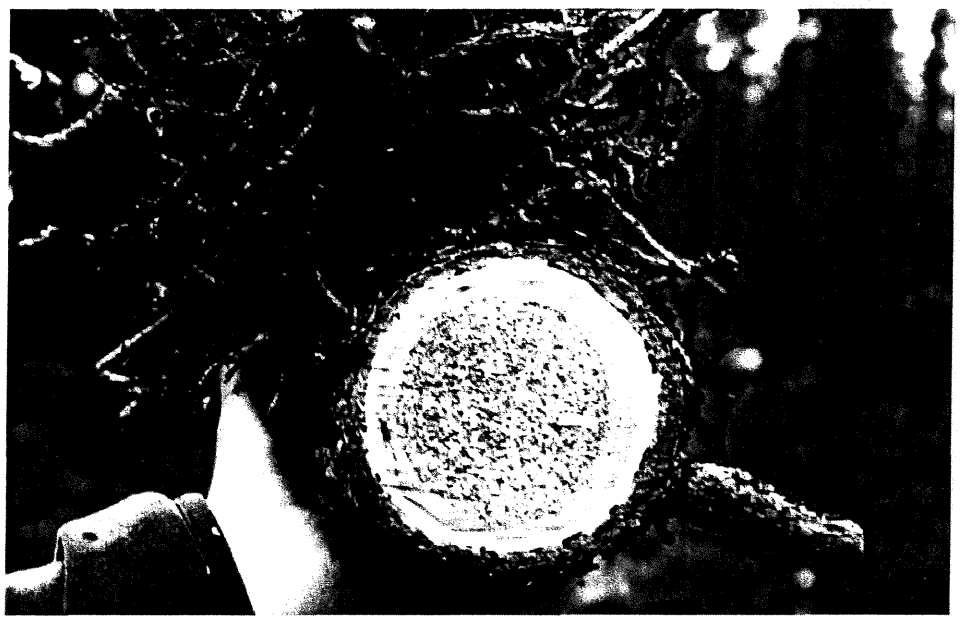


Figure 7. *P. chrysoloma* advanced decay in association with a dead spruce rust broom.



Appendix A

Phellinus chrysoloma (Fr.) Donk
White pocket trunk rot

Hosts: White spruce, black spruce, Sitka spruce, western and mountain hemlock, and lodgepole pine. Both live and dead trees can be attacked.

Distribution: Throughout the host range in Alaska.

External signs: Conks are perennial, shelf shaped, hard, and woody. The upper surface is dark brown with concentric rings and a narrow, velvety, golden brown margin. Lower surface is gray brown to dark brown with pores. A thin black layer, visible with a hand lens, separates the upper surface from the lower surface. Fruiting bodies are variable in size, but typically 1 to 3 inches across, and often grow closely stacked on top of one another. On fallen trees, conks may develop in rows. Punk knots, decayed branch stubs, are filled with the same substance of the interior of a conk. Punk knots may appear swollen and may be overgrown so that the punk is hidden unless the knots are chopped open. Sunken resinous cankers, caused by the fungus, may develop on the stem of infected trees.

Decay: The incipient stage appears as a light purple to gray discoloration, later changing to red brown. Wood with advanced decay is typically discolored a red/brown and contains elongated, sharply margined, spindle-shaped pockets parallel to the grain. Decay pockets may be empty or contain soft, white fibers. Narrow black or brown zone lines may be present in the decayed wood.

Damage and Control: This fungus causes a white pocket rot that can extend the entire length of the bole. It infects and decays the heartwood of living trees and can continue to decay dead trees. Control is through shortened rotations and removal of trees with conks.

Notes: A closely related species, *Phellinus pini*, is also present in Alaska on the same conifer host species. The two *Phellinus* species produce similar sporophores and decay except that *P. pini* sporophores are larger, tend to form singly rather than in clusters, do not form in rows on dead trees, and lack the thin black layer that separates the upper conk surface from the lower surface. Also, *P. pini* does not typically act as a canker-rot pathogen.